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Cost-Benefit Assessment of
Interactive Electronic Technical
Manuals in Navy Training and
Education

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14. ABSTRACT Interactive Electronic Technical Manuals (IETMs) are devices originally developed to aid technicians in the performance of their jobs by accelerating information retrieval, aiding equipment diagnosis and repair, and facilitating record keeping and logistics management. Navy trainers have discovered that IETMs also can help the technician learn. The Navy asked the Logistics Management Institute to assess the potential costs and benefits to the Navy of acquiring IETMs, not only from an operational perspective, but from the training and education perspective as well. We were asked to characterize how the Navy acquires these devices, how they are used, and what resource impacts result from their acquisition and use in training venues. In this report, we describe the acquisition and management structures in the Navy that develop and procure IETMs. We also report what Navy programs are buying and why. We characterize the costs and benefits the Navy is likely to see with the use of IETMs in classrooms and job sites. We gathered anecdotal experience data to assess the impacts IETMs are having in Navy training and operational venues.					
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Executive Summary

The Navy trains thousands of sailors each year in the individual skills required to do their jobs. The cost of training these students in institutional settings is enormous; it consists of classroom direct and overhead costs, student and instructor pay and allowances, and courseware acquisition and maintenance, among other costs. The application of new training technologies promises to reduce some of these costs. The Navy, like its Service counterparts, is searching for the technology or combination of technologies that will provide the greatest training benefit and reduce the costs of training sailors.

Interactive electronic technical manuals (IETMs) are devices that originally were developed to aid technicians in the performance of their jobs by accelerating information retrieval, aiding equipment diagnosis and repair, and facilitating recordkeeping and logistics management. Navy trainers have discovered that IETMs also can help the technician learn. The Navy wants to exploit this discovery by characterizing and developing the training potential of IETMs with the aim of more efficiently training technicians and, ultimately, saving Navy time and resources.

The Navy asked the Logistics Management Institute to characterize how the Navy acquires IETMs, how they are used, and what resource impacts result from their acquisition and use in training venues. We were asked to assess the potential costs and benefits to the Navy of acquiring these devices, not only from an operational perspective but from the training and education perspective as well. We were also asked to build a computer-based tool to help the N81 analyst assess the relative cost-benefits of alternative IETM programs.

Our research found that, although there is general guidance asking that program offices acquire digital technical information where it is deemed "cost effective," there is no accompanying guidance on how to measure cost effectiveness. Furthermore, there is almost no binding direction regarding the form or function of IETMs. Hence, program offices are acting autonomously—and the result is that the Navy is buying devices with many widely differing formats and capabilities.

Also, logistics acquisition planners and training planners work in distinct “stovepipes” that hinder collaboration on IETM development.

We found that the predominant incentive for buying IETMs appears to be their potential savings in production, distribution, and maintenance relative to paper manuals. Because the cost of technical manual development and conversion increases tremendously with the functionality of the device, most acquisition managers are buying the lower end, or Class 1 and 2, IETMs.

There are several suppositions about the impact that IETMs could have on institutional training and job-site training and operations. Unfortunately, there is very little empirical data with which to substantiate the claims. We gathered anecdotal evidence, the assessment of which leads us to conclude that there are indeed savings and other benefits to be gained by using IETMs as training tools. Many results were mixed, however, and the magnitude of the IETM’s impact often was overstated. To date, there has been little documented improvement in “street-to-fleet” time—a prime indicator of training efficiency—for apprentice-level technicians.

Based on these findings, we conclude that a focused pilot study is needed to collect data with which to quantify the impact of IETMs and other training technologies. We also conclude that an assessment of emerging training technologies and competing plans and guidance is essential. The assessment would help to create a Navy enterprise plan for training technology development and deployment.

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Chapter 1

Introduction

BACKGROUND

Technical manuals (TMs) are publications that contain instructions for the installation, maintenance, and support of defense systems, system components, and support equipment. TMs can be traditional paper documents; electronic technical manuals (ETMs), which display the traditional page-based information on a computer screen; or interactive electronic technical manuals (IETMs), which are smart databases of text and graphics, arranged and presented in pageless, frame-oriented, interactive formats.¹

IETMs streamline access to information and provide multiple paths to related information. Depending on the level of sophistication, an IETM can duplicate on a personal computer or other display device the research environment available in a well-equipped reference library. Powerful interactive troubleshooting procedures and tutorials, which are not possible with paper technical manuals, can be made available by using the intelligent features of the IETM display device.

The entire Department of Defense (DoD) is moving to digitize as much technical information and logistical data as possible. This effort includes a mandate to procure or convert equipment TMs into digital formats wherever practical. The TM digitization movement initially was driven by the fact that printing, distributing, maintaining, and storing paper technical publications was consuming increasing resources and using large amounts of infrastructure. The digitization effort also has been spurred by research that indicates that digital information systems are not only less costly but more effective and efficient to use in their primary role of supporting system operations and maintenance than paper-based products.²

There also is an emerging body of research that suggests that prudent and effective employment of interactive courseware (ICW) in classrooms can enable courses to reduce in-classroom time by 10–40 percent. Moreover, when trainees learn at their own pace, they learn better, retain more, and understand when and how to apply what they have learned.

The Navy wants to leverage all of these potential benefits of IETMs and ICW to achieve maximum effectiveness and efficiency from its training and its opera-

¹ Office of the Secretary of Defense, *Program Manager's Desktop Guide for Continuous Acquisition and Life-Cycle Support (CALS) Implementation*, 1997.

² Eric L. Jorgensen, *The Move to Paperless Technical Manuals in the US DoD*, Naval Surface Warfare Center, Carderock Division, undated.

tions. The Assessment Division (N81) within the Office of the Chief of Naval Operations (OPNAV) asked LMI to assess the potential costs and benefits of acquiring IETMs for new and legacy systems. Unlike previous research in this field, however, this investigation assesses this potential from the training and education perspective. N81 theorizes that the prudent application of IETMs will reap monetary savings and operational benefits for the training and education environment as well as for the fleet.

PURPOSE

The purpose of this research is to

- ◆ assess the potential costs and benefits to the Navy of acquiring IETMs,
- ◆ characterize how the Navy acquires IETMs,
- ◆ characterize how the Navy uses IETMs,
- ◆ develop an analytical tool for analyzing alternative IETM programs, and
- ◆ describe the resource impacts that result from IETM acquisition and use.

Discussion of the analytical tool can be found in LMI Report NA008T2, *Interactive Electronic Technical Manual Cost-Benefit Analysis Tool User's Guide*.

APPROACH

First we conducted an extensive literature and media search and interviewed policymakers in the Navy to understand what the Service is doing with regard to acquiring IETMs—who manages the process, what rules and standards govern the process, and what goals or imperatives drive the Navy's policies.

Next we gathered and assessed quantitative and qualitative information about the use of these devices in institutional training settings and at the Fleet. The magnitude of the data deficit became clear during this phase of the study. There is no central repository of IETMs experiential data (or even repositories local to systems commands), so we captured anecdotal data by studying a few high-visibility cases. We refer to the experiences of these cases frequently in this report.

We also assessed some selected sample data from the incorporation of IETMs into Advanced Electronic Classroom (AEC) technology suites. Those data give us a look at the potential impacts of IETMs in institutional training.

Finally, we developed an analytical framework to help analysts compare alternative technology acquisition programs. Although the model was developed with IETMs in mind, the basic framework can be re-used to conduct many analyses, such as alternative classroom technology or distance learning assessments. The

model and its documentation are being provided to N81 under separate cover (see LMI Report NA008T2).

CHALLENGES AND CAVEATS

- ◆ According to staff in the Office of the Director of Naval Training (N75), “To date, there are no good studies that show costs-benefits of the application of IETMs to training.”³ Neither of the military services has contracted for in-depth study of the potential of IETMs—in part because it would take significant time and money to study the issues. Moreover, no two programs appear to use the same analytical justification for acquiring IETMs. And, as we found during our research, there has been little concerted effort to collect data on IETM procurement or implementation.
- ◆ Empirical data on the use of IETMs in the Navy are nearly nonexistent. Experience data for IETMs use, either in schoolhouses or operational settings, have not been collected to any significant degree. We assess *anecdotally* the costs and benefits for the Navy, from training and education as well as organizational-level logistics perspectives, of acquiring IETMs in lieu of paper TMs.
- ◆ We acknowledge that current DoD and Navy directives call for all acquisition programs to procure or convert all technical information into digital formats for delivery.⁴ Because all of DoD is moving toward the use of digital technical information for all new and legacy equipment, maintaining paper manuals is an unrealistic alternative; we used that scenario in this assessment only as a statement of the status quo. Because program offices are required to assess the cost-effectiveness of acquiring TMs in digital form, however, our assessment compares IETM classes to paper-based operations and training.
- ◆ We do not address requirements determination in our discussion. We start our analysis from the assumption that the argument already has been made to procure IETMs. We understand that ideally, IETM class selection and functionality would be driven by the operational requirements spelled out in the basic system’s concept of operations (CONOPS).
- ◆ We do not address the cost of training infrastructure (i.e., schoolhouse facilities) in our assessment. Costs associated with institutional training facilities are assumed to be sunk costs.

³ Interview with Tim Tate, N75, 2 March 2000.

⁴ DoD Regulation 5000.2-R and DON’s *Guidance on Acquisition and Conversion of Logistics Technical Data to Digital Form*, July 1999, dictate that technical data for new systems be procured in digital form and that data for legacy systems be converted to digital form “when conversion is cost-effective.”

-
- ◆ Whether procuring a new IETM or considering conversion of an existing TM to an interactive digital format, the development and procurement costs are only a fraction of the total life-cycle cost of the TM. There are costs associated with incorporating the devices into classroom technology suites, costs to maintain and update the device and its data, and costs and benefits of using the devices to train students and maintain equipment. No existing cost model facilitates a rigorous analysis to select the optimal, most cost-effective level of TM automation that address each of these components. Unfortunately, this situation tends to focus attention on the costs of conversion rather than a true understanding of the total impacts.⁵

IETM TECHNOLOGY

As a benefit to the reader, we provide a basic understanding of IETM technology before proceeding to the remainder of this report. The following subsections describe the basic features and capabilities of these devices.

General Description

An IETM is a computer-based collection of information needed for the diagnosis and maintenance of a defense system. An IETM enables the user to locate required information faster and more easily than is possible with a paper technical manual. When IETMs are designed to DoD specifications, they are easier to comprehend, more specifically matched to the system configuration under diagnosis, and available in a form that requires much less physical storage space than paper.

In general, an IETM is optically arranged and formatted for interactive presentation to the end user on an electronic display system. Unlike other optical systems that display a page of text from a single document, IETMs can present interrelated information from multiple sources tailored to user queries.

IETM Classes

Although IETMs generally are easier to use than paper manuals, there is a wide range of capability and usability. These capabilities are captured in categories called classes. Table 1-1 provides a description of the classes.

⁵ Commander, Naval Sea Systems Command and Commander, Space and Naval Warfare Systems Command, *Interactive Electronic Technical Manual (IETM) Process Plan*, 5 December 1995.

Table 1-1. IETM Classes

IETM class	Description
0	Non-electronically indexed page images
1	Electronically indexed pages images
2	Electronic scrolling documents
3	Linear structured IETMs
4	Hierarchically structured IETMs
5	Integrated database IETIS

The lowest classes of IETMs usually are referred to as ETMs instead of IETMs because they offer no interactivity; they are merely digitized images of paper pages. Class 0 has no indexing whatsoever, so the user must view page after page to access any information. Class 1 is similar to Class 0 but may include a basic level of indexing that enables the user to “jump” to desired chapters or sections. Classes 2 and 3 incorporate the basic functionality we typically require of an IETM. Class 2 IETMs usually consist of American Standard Code for Information Interchange (ASCII) or portable data format (PDF) files in a linear format that offers the user the capability to search, browse, and hyperlink to selected topics. Class 3 adds the first real interactivity by including dialog boxes. Class 3 data usually are in Standard Generalized Markup Language (SGML) format, with content tags rather than the format tags found in the Class 2 device. Class 3 also adds the logical “next” and “back” functions to the device’s capability.

The real advance in IETM formats occurs between Class 3 and Class 4. Class 4 and 5 devices use database structures rather than the linear document structures of the lower classes. This arrangement allows for much more flexible cross-referencing. The interactive features of the Class 4 device usually are integral to the authoring process rather than added on after the content is written. Finally, the Class 5 device really is a multifunctional integrated electronic technical information system (IETIS) that enables the user to interface with other databases, maintenance and diagnostic systems, administrative and logistical systems, and more.⁶

The higher the class, the more technologically complex the IETM. Early work by researchers at the Naval Surface Warfare Center-Carderock Division (NSWC-CD) demonstrated the benefits of IETMs over paper-based manuals. The benefits increase with each higher class. The lowest classes (0 and 1) have correspondingly lower production costs because for the most part they are merely electronic versions of the paper products. The higher classes (4 and 5) have the greatest potential to affect how maintenance training takes place. We address this potential in greater detail in subsequent chapters of this report.

⁶ Draft Navy *Interactive Electronic Technical Manual (IETM) Process Plan (IETMPP)*, 54.

ORGANIZATION OF THE REPORT

The remainder of this report is structured as follows:

- ◆ Chapter 2 reports the findings of our background research into IETMs. We describe the Navy's organizations and processes that affect how IETMs are developed and acquired.
- ◆ Chapter 3 presents the IETM acquisition and cost experiences of some high-profile programs. It also describes the processes and costs involved in converting from paper manuals to ETMs or IETMs.
- ◆ Chapter 4 focuses on Navy training and the potential that IETMs offer to make training more cost effective.
- ◆ Chapter 5 recaps our analysis and findings and discusses the insights generated by the findings. We draw conclusions about what actions the Navy might wish to take to understand and realize the full potential of IETMs.

Chapter 2

IETMs and Navy Acquisition

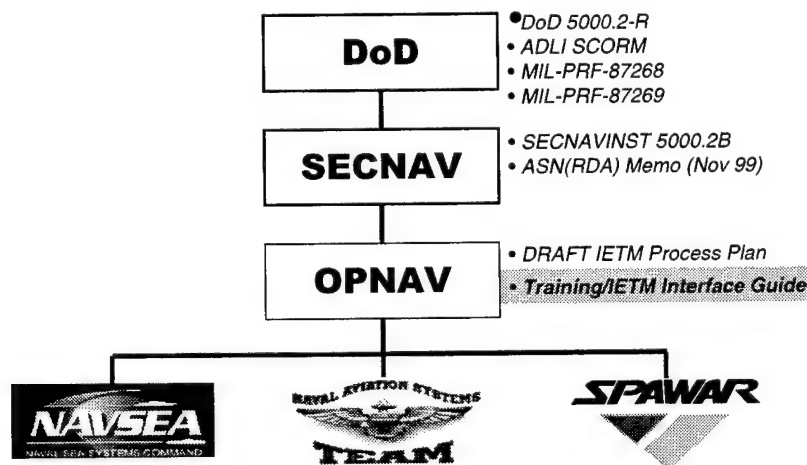
One of our primary tasks was to characterize the process of acquiring IETMs in the Navy. We wanted to understand who does what with regard to IETM development and acquisition policy and what imperatives, if any, Navy acquisition program offices are responding to.

In this chapter, we identify and evaluate the organizations and offices responsible for IETMs development and acquisition. We also address some of the key issues Navy programs face in the development and acquisition of IETMs.

IETMs DEVELOPMENT AND ACQUISITION POLICIES

Figure 2-1 shows, very simply, how the Navy guides the development of IETMs. The process is not directive; in fact, there is very little binding guidance involved. Virtually all of the guidance deals only with the form and structure of the delivery of logistics technical data. There is little written about the content or functionality of the devices, and almost no mention is made of IETMs' role in training.

Figure 2-1. IETMs Guidance



At the DoD level, there is a single paragraph in the capstone acquisition regulation that directs acquisition program managers to obtain logistics and maintenance documentation in digital form only if it makes economic sense. The Department also has promulgated two performance specifications that establish minimum standards for presentation of maintenance and logistics information. DoD also chairs a cross-service working group that promotes collaboration and cooperation in the development of distributed learning technologies throughout DoD. That

working group has developed the Advanced Distributed Learning Initiative (ADLI) Shareable Courseware Object Reference Model (SCORM), which contains *suggested* standards for digital learning objects.

The Navy has incorporated language into its acquisition regulation that simply directs Navy Program Managers (PMs) to follow the guidance in the DoD regulation. The Assistant Secretary of the Navy for Research, Development, and Acquisition (ASN[RDA]) has signed a policy memorandum that—in addition to directing PMs to follow the guidance in DoD and Navy regulations—addresses standards for delivery of digital data.¹ There is no mention of training requirements in any of these publications, however.

The Navy developed the Draft IETM Process Plan (IETMPP), ostensibly to ensure that all programs use a comprehensive approach and standard methodology to create or convert to digital TMs. The IETMPP, however, allows programs “to flexibly determine an appropriate IETM strategy, given their respective program requirements, while ensuring standard processes that enable the DoD to continue to support these new logistic products using the centralized logistic management systems currently in place.”² Thus, though the IETMPP’s intent clearly is reasonable, this document does not establish IETM development rules to which acquisition programs *must* adhere.

The one document we found that addresses training to any significant degree is the N7-produced Training/IETM Interface Guide (T/IIG).³ The T/IIG advises logistic element managers and technicians on training tools, including their implementation processes, and on items that can affect IETM development. As its name implies, however, the T/IIG is only a guide; it does not carry directive authority over acquisition programs.

The IETMPP and the T/IIG are designed to be complementary. The IETMPP takes precedence. Executive authority for life-cycle management of the IETMPP is delegated to the Navy Technical Manual Working Group via OPNAV N4. T/IIG life-cycle management is delegated to the Naval Air Warfare Center-Training Systems Division (NAWC-TSD) via OPNAV N7.

Although the N7 experts we interviewed indicated that propensity for IETMs rests with the Navy logisticians (N4), we were not able to find an N4 office that claims any directive authority with regard to the acquisition of IETMs. Moreover, the program offices we surveyed were only generally aware of the foregoing guidance documents. Also, it is clear that logisticians who have primacy for IETM development and the training planners in N7 work in separate and distinct “stovepipes.” The opportunities for N7 to influence IETM acquisition strategy are limited.

¹ ASN(RDA), Memorandum for Distribution, *DON Policy on Digital Logistics Technical Data*, 2 November 1999.

² Draft, *Interactive Electronic Technical Manual (IETM) Process Plan*.

³ Chief of Naval Operations (N7), *Training/IETM Interface Guide*, 1999.

Assessment

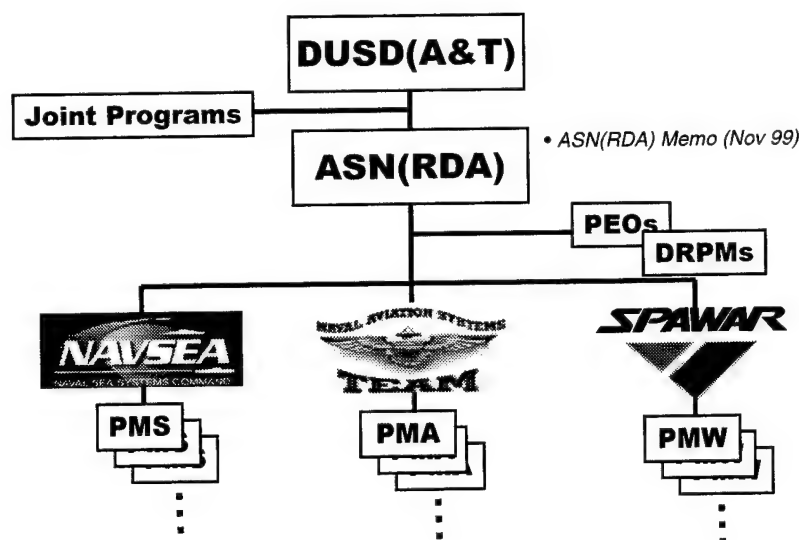
Except for the mandate to move away from paper-based technical information to information systems-based manuals, the Navy's guidance regarding what IETM end products should be is quite general. Most current development and acquisition activity is centered around the effort to convert paper manuals for legacy systems into electronic manuals. This effort is meeting with varying degrees of difficulty. In some instances, the nature of the legacy manuals imposes limitations on the work that can be performed—some data simply do not lend themselves to sophisticated conversion. Updating the information before realistic SGML or XML conversion could be conducted would take considerable time and money.

Nevertheless, there is general understanding that all TMs eventually must be put into digitized formats that allow for some interactivity. There are external standards—mainly commercial or industry-driven—to which many of the developmental IETMs are being engineered. At the same time, the standards for the presentation of maintenance/logistical information are converging with those for the production of ICW. This convergence, however, seems to be a function of technology evolution rather than any intentional migration by IETM developers.

IETM ACQUISITION MANAGEMENT

The acquisition of IETMs is largely a bottom-fed process, with requirements developed at the program level (see Figure 2-2). Acquisition program offices are nearly autonomous and have freedom to acquire IETMs as they choose. (The programs, influenced by their specific contractor situations, are pursuing widely differing solutions.) Thus, although many personnel at the Systems Command (SYSCOM) and higher levels see the need for standardization and interoperability, there are limited incentives for the programs to push very hard toward that goal.

Figure 2-2. IETM Acquisition Management



Regarding acquisition guidance, there is some documentation governing acquisition of IETMs, but it is mostly suggestive of how the devices should be bought. Although there is a “Technical Manual Acquisition Strategy” component in the DoD acquisition documentation, that handbook provides only guidance for program managers on how to contract for and price the new digital technical data. The Secretary of the Navy (SECNAV) memorandum, the IETMPP, and the T/IIG each contain guidance for acquisition program managers. None of these documents, however, actually defines a Navy-wide strategy for development and acquisition. The focus of these publications is the conversion of existing paper maintenance manuals into digital formats. The stovepipe culture is clearly evident at the SYSCOM level also.

Assessment

Navy acquisition of IETMs is driven by maintenance and logistics considerations as opposed to training issues. Imposing widely accepted and consistent training influence will be a challenge. Technical manuals, which are targeted mainly to maintenance and logistics purposes, are procured by the acquisition/logistics community. Training courseware, of course, is procured by the training community. The two rarely interact. The “rice bowl” culture must be addressed before true reform of this process can take hold. Until then, realizing significant training benefit (or even realizing the vast potential maintenance/logistics cost-benefit) will be difficult.

SUMMARY

The Navy’s IETMs acquisition process is extremely decentralized. Acquisition program offices are nearly autonomous and have the freedom to acquire IETMs as

they choose. The program offices, influenced by their specific original equipment contractors, are pursuing widely differing ETM/IETM solutions. While this approach is not bad in theory, in practice it limits sharing and co-use opportunities.

Moving to a consistent electronic format for technical information has been a difficult process within the Navy. In part this is related to an easing of standards under acquisition reform and the growing shifting of design responsibilities to the contractor. Furthermore, because both the logistics community and the training community have an interest in the acquisition and implementation of IETMs, the Navy would probably benefit by establishing a lead agency to provide coordinated direction and guidance.

Chapter 3

IETM Costs and Benefits

In this chapter, we examine the extent of IETM acquisition and use within the Navy. We then address IETM development and conversion processes, costs, and operational benefits that IETM users expect. We illuminate each of these topics with anecdotal data from selected acquisition programs.

IETMs IN THE NAVY

We interviewed each of the SYSCOMs and many of the programs and venues identified by SYSCOMs and OPNAV staff as having significant IETM programs to determine the extent of IETM procurement by the Navy. Table 3-1 attempts to address this question. The numbers do not represent the totality of IETMs being procured by the Navy but a substantial subset, based on our interviews.

Table 3-1. IETM Population by SYSCOM

	NAVSEA	NAVAIR	SPAWAR
Class 1	1040	3882 ^a	2
Class 2	327	0	14
Class 3	49	5	2
Class 4	56	3	4
Class 5	634	1	14

^aRepresents all PDF manuals on NATEC Website; some of these manuals have Class 2 functionality.

Naval Sea Systems Command (NAVSEA) and the Space and Naval Warfare Systems Command (SPAWAR) data were taken from the Technical Data Management Information System (TDMIS) managed by the NSWC-Port Hueneme Division (NSWC-PHD). Naval Air Systems Command (NAVAIR) data were taken from the Naval Air Technical Data and Engineering Service Command (NATEC) database managed by NATEC headquarters at San Diego, CA.

Clearly there are anomalies here. For instance, we do not believe the Navy is buying 649 Class 5 IETMs. Based on our discussions with NATEC database representatives, we believe that the classes of some of these IETMs are overstated. Some system programs that claim to be acquiring Class 5 IETMs actually are getting Class 4 IETMs, and so on down the line. Unfortunately, IETM descriptions are sufficiently vague that an accurate audit is impossible. The insight to be gained, however, is that NAVSEA and NAVAIR appear to be either doing the minimum or going all out. They are not investing much in the middle-of-the-road

capability. In general, the newest NAVAIR aircraft platforms are acquiring at least Class 4, whereas the vast number of manuals for legacy aircraft are being converted to Class 1/2. The SPAWAR data probably are insufficient to enable us to draw a good conclusion.

IETM CHARACTERISTICS, COSTS, AND BENEFITS

IETM Desired Characteristics

The introduction to IETMs at the end of Chapter 1 shows the range of capabilities IETMs may possess and explains the relative benefits of each. What are equipment developers looking for in an IETM? Our interviews with stakeholders on the Navy staff and at the SYSCOMs resulted in the following list of desired features for IETMs:

- ◆ Interactivity
- ◆ Friendly interface (“look and feel” qualities)
- ◆ “Smart” (guides user through procedures)
- ◆ User/learner-centered (“tailorable” to the user)
- ◆ Hierarchical, revisable database (for flexibility)
- ◆ Automated access, searchable “tagged” content
- ◆ Technical standards that allow reuse
 - Authoring in SGML or Extensible Markup Language (XML)
 - Data formats not tied to display formats
 - Multifunction display
- ◆ Nonproprietary viewing software.

For maintenance job aiding and for training functionality, these attributes describe a device that tailors its output to the user’s information requirements in a logical, ergonomic way. The device employs some degree of artificial intelligence to make the right information available in the right context at the right time. It is interoperable with other automated systems the user must employ and can be used as effectively in an institutional training environment as on the job site.

Acquisition and Conversion Processes

The IETMPP developed by NAVSEA contains considerable guidance on the steps required to acquire or convert technical data. The plan captures the relative difficulty of doing each task, as well as the pros and cons, in great detail. The following paragraphs summarize the major points that program offices must consider.

TMs can be converted to any class of IETM from existing hard-copy TMs, or the technical data can be acquired as Class 2 or higher source data from the authoring contractor or government activity. Acquisition involves a slightly different decision-making process than conversion.

Although Class 4 and Class 5 IETMs provide significant savings in maintaining and updating the data, the costs of conversion are high. The high cost is related to reauthoring, or redesigning legacy data to take advantage of advanced functionality. The major costs of conversion are in

- ◆ developing the hierarchical structure;
- ◆ reauthoring the legacy TM to prepare data for use in a database;
- ◆ selecting the level of granularity (or detail) for decomposing each section;
- ◆ reauthoring and cleanup to eliminate repetition and redundancy;
- ◆ adding photographs, animations, movies, verbal instructions, and other supplemental enhancements;
- ◆ naming common and unique data objects and linking them into a logical presentation; and
- ◆ validation of reauthored information.

When higher-class IETMs are created from scratch, the level of data indenture and granularity is optimized at the lowest or smallest level (i.e., the step). For conversions, the costs of driving all TM data down to this optimal level may be prohibitively high. This is not the only logical option, however. Class 4 and Class 5 IETMs can be developed with the objects that are roughly the same size as comparable objects in Class 2 or Class 3 IETMs (e.g., one paragraph or a procedure). By minimizing the handling of objects and substantially reducing the reauthoring desired or required, conversion costs can be reduced to the same range as those for Class 3. This IETM would have the presentation features found in a normal Class 4 or Class 5 IETM, but it would not be as robust. This compromise retains some redundant data, sacrifices some database maintenance efficiency, requires more update effort, and reduces some flexibility. Although some of the data may always remain in the initial conversion state, the program has the option of incrementally reauthoring specific sections of the TM (e.g., troubleshooting) down to the appropriate level of indenture (e.g., step).

Most TMs are involved in or already have completed major technical data conversion efforts. These efforts primarily encompass conversion from hard copy (paper or aperture cards) to Class 1 (raster) or Class 2 (indexed PDF) formats. Therefore, many future conversions may be from one of these formats rather than from the original data format. For instance, instead of having to convert from paper to a Class 4 IETM, the data would be converted from a Class 2 IETM to a Class 4 IETM, with an associated reduction in conversion cost.¹

The formal Class 5 IETM consists of a Class 4 IETM that shares an integrated database with other associated applications. Consideration should be given to the data configuration issues entailed when multiple logistics databases are integrated into a single database.

Acquisition and Conversion Costs

Obtaining acquisition cost data for IETMs was far more difficult than we had anticipated. The reasons were many. First, the total acquisition cost for an IETM often is buried in numerous separate line items within a program, which typically are too difficult to resolve. In other cases, the cost data are doggedly guarded by the manufacturer or government program office, which was unwilling to provide us with an estimated cost. Other times, the data are buried in Contract Logistics Support (CLS) documentation. Still other data are unique and are difficult to combine with analogous data from similar systems.

Nevertheless, some cost insight can be obtained from paper-to-electronic conversion costs. We obtained conversion cost estimates for each class of IETM, which are shown in Table 3-2.

Table 3-2. Cost of Converting Paper Manuals to IETMs

Interactivity	Description	Class	Savings	Cost/page
Low	Raster scanned with indexing	1	Weight/space	\$2
Moderate	Intelligent	2		\$2-\$10
Good	Interactive to user (printable)	3		\$10-\$25
High	Interactive to user (objects)	4		\$40-\$100+
Full	Interactive to user and associated systems	5	Training fleet/data maintenance	\$200

Source: Draft IETM Process Plan, February 1998, 2-39.

¹ IETM Process Plan, 2-41

NAVSEA Case Study

We found that the costs listed in Table 3-2, which were included in the IETMPP, generally matched the costs experienced by the people actually buying IETMs today. We also can generalize ETM costs from some recent NAVSEA conversion data.² To convert to raster (ETM), NAVSEA costs are about \$0.50 per page (for the average hull, mechanical, and electrical [HM&E] book); if one estimates that each HM&E book is about 100 pages on average, the cost to convert is about \$50 per book. A typical IETM may combine up to 100 manuals. Thus, a low-level ETM may total about \$5,000 in conversion costs.

NAVSEA costs for converting from paper to SGML Class 3 are about \$12.50 per page. Half of that amount is the cost of conversion from text to SGML, and half is for quality assurance (QA) of data files. Some legacy paper manuals are converted to higher-level (Class 3/4) IETMs, but this type of conversion generally is very difficult and expensive, particularly with regard to QA.

Many NAVSEA and SPAWAR programs are using Raytheon's Advanced Integrated Maintenance Support System (AIMSS™) to develop Class 4 and Class 5 devices with costs of \$200–\$250 per page-equivalent. They report that there are heavy QA costs associated with this process.

NAVSEA generalizes that an SGML ETM costs about one and one-half times what buying paper manuals costs but that update costs are about one-quarter those of paper documents. They also conclude that the reduced update costs for IETMs will result in reduced life-cycle costs that will enable programs to recoup their investments over relatively short durations (2 to 5 years). Also, the IETM advantage is increasing because the costs for electronic manuals are decreasing. (In fact, Microsoft has come out with an "SGML author" add-on for Word for Windows, which should reduce the cost of this authoring process further.)

Operational Benefits of IETMs

The feasibility and desirability of using IETM systems to support military technicians in the operation, maintenance, and logistical support of weapon systems have been accepted by all military services, although no service has maintained substantial records of benefits sustained to date. NSWC collected anecdotal evidence of maintenance improvements resulting from the use of IETMs for eight selected projects in the mid-1990s.³ The maintenance-specific findings were that the use of IETMs

- ◆ reduced false alarm rates,

² Correspondence with Martin Cohen, NAVSEA Philadelphia, Technical Manual and Training Branch.

³ Eric L. Jorgensen and Joseph L. Fuller, Naval Surface Warfare Center, Carderock Division, *Analysis of Eight Navy Projects Accruing the Training Benefit of the Accelerated Use of IETMs*, 21 March 1996.

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- ◆ increased successful fault isolations,
 - ◆ reduced fault isolation times,
 - ◆ reduced false removal rates,
 - ◆ increased the effectiveness of inexperienced technicians,
 - ◆ improved personnel and equipment safety,
 - ◆ reduced cycle time for technical manual deficiency reports (TMDRs), and
 - ◆ reduced technician time for maintenance reporting and parts ordering.

The F/A-18 program has made the argument for IETMs on the basis of expected reduction in false removal rates of good components. False removals of components thought to be faulty—but eventually found to be good—were such a problem that a reduction of less than half this rate in the short run paid for the acquisition of IETMs. Researchers at NSWC-CD found some supporting evidence.⁴ Their study, performed in the early 1990s, compared two groups of aircraft technicians performing fault-isolation tasks. One group used conventional paper-based technical manuals and the other an IETM displayed on a portable computer. The test results showed considerable reduction in performance times for complex, multiple-fault isolations and reduction of maintenance errors when technicians used the IETM/portable computer combination.

In another study, maintenance technicians using a computer-based electronic document with artificial intelligence assistance on troubleshooting completed tasks in less than half the time personnel using paper manuals required. Novices using the electronic job aid could troubleshoot 12 percent faster than experienced technicians using paper manuals.⁵

IETMs also have the potential to affect training. During limited pilot projects conducted in the mid-1990s, for example, Navy researchers demonstrated that the use of IETMs could increase the performance levels of inexperienced technicians to that of experienced technicians in complex tasks such as fault isolation. IETMs also can reduce the time required to provide a student with a given level of tech-

⁴ Mark T. Kramer, Theodore J. Post, and Samuel C. Rainey, Naval Surface Warfare Center, Carderock Division, *Results of a Joint Navy/Air Force Operational Test to Evaluate USAF Integrated Maintenance Information Systems (IMIS) Interactive Electronic Technical Manual (IETM) Technology Applied to the F/A-18 Aircraft*, 14 June 1993.

⁵ W. A. Nugent, S. A. Sander, D. M. Johnson, and R. J. Smillie, *Troubleshooting Performance Using Paper and Electronic Documentation*, Naval Personnel Research and Development Center, Technical Note 87-41, 1987.

nical competence.⁶ We address the costs and benefits of using IETMs in Navy training in Chapter 4 of this report.

Summary of Findings

Costs unique to IETMs are added to the costs of acquiring equipment technical information. The true costs of IETMs begin with the design (or authoring) of the digital functionality for accessing and using the technical information. This analysis implies a level playing field for comparison with paper manuals. It does not make allowances for the possibility that, conceptually, there may be a difference in the cost of supplying data for digital authoring versus supplying data in a form that will allow for reading into linear files and formatting for eventual printing on paper.

Most IETM-specific development costs relate to software development. Interestingly, the costs at this stage have less to do with the volume of information and likely are in proportion to the complexity of the item and the level of interactivity and functionality the user desires. The actual conversion or coding, however, does incur a value-driven cost that is similar to that shown in the matrix in Table 3-2. The higher the IETM class, the more expensive the development alternative.

Naturally, there are publication and distribution costs for printing and mailing compact discs or authoring and posting Web-based products. This “fielding” cost, which is significant for paper manuals, typically is small in relation to development cost for IETMs. The larger the quantity of manuals required, the larger the IETM production and distribution advantage.

The IETM display chosen also may add significant cost. If the IETM uses standard PC platforms that are resident at most schools and units, little or no additional investment may be required. On the other hand, if the IETM includes the display device, the choice ranges from a commercially available, Internet-ready computer at about \$500 each to military-hardened Portable Electronic Display Devices (PEDDs) that can cost tens of thousands of dollars. Typically, PEDD costs vary by capability and quantity procured.

Finally, there are life-cycle support costs. These recurring costs apply regardless of whether the IETM is used in a training or operational environment. The one recurring cost that is highlighted most often as a benefit of IETMs over paper manuals is the cost of performing technical manual updates and changes. Navy organizations could save significant time and money posting and implementing updates and changes with IETMs than with paper manuals. The costs of updates vary widely, depending mainly on the frequency and complexity of the updates and the means of distributing the changes. Personnel with whom we spoke agree

⁶ Eric L. Jorgensen, Joseph J. Fuller, Theodore J. Post, and Samuel C. Rainey, NSWC Carderock Division, *Potential Benefits to Navy Training Programs Resulting from Increased Use of Interactive Electronic Technical Manuals*, October 1995.

with this projection but were unable to produce data to provide a magnitude to the projected savings.

Insights

We found several themes on a recurring basis during our investigation. First, despite the inertia of a system that has long relied on paper manuals, there is a concerted movement by all acquisition and logistics communities to acquire technical data in digital form or to convert paper manuals for electronic display. The design of resulting IETMs is almost solely dependent on program finances or on operational concerns, however. Training and logistics planners generally do not integrate their efforts.

Many new IETMs require proprietary viewers, making them expensive to acquire and maintain and limiting their co-use possibilities. For example, the three major aircraft programs we researched all experienced some problems stemming from the use of proprietary elements in their IETMs. Also, the Gas Turbine Maintainer's (GS) course at Naval Training Center (NTC) Great Lakes had an experience that demonstrates the dangers of using proprietary material. The Chief of Naval Education and Training (CNET) contracted with an original equipment manufacturer to provide a training package to support the gas turbine engine course. The contractor modified a nonproprietary IETM and overlaid a proprietary training package. Now, neither the IETM used by the schoolhouse nor the training package can be modified without a significant outlay of funds. The package has been unmodified since delivery in 1994. Not surprisingly, this situation affects the quality of training that GS school students receive because they are using a somewhat outdated training tool.

The Vertical Takeoff and Landing Unmanned Aerial Vehicle (VTUAV), on the other hand, is a blend of original and legacy technical manual development whose contract requirement specifies nonproprietary software, with heavy reliance on commercial-off-the-shelf (COTS) technology. The Acoustic Research COTS Integration (ARCI) program may be considered a model program. The government/contractor team is developing a Class 4 IETM that uses nonproprietary software. Operations and training are being designed integrally, and the IETM is being used in training as part of an AEC. The devices will be reusable among many systems (although with the ARCI program, the IETM cannot be updated via the Web because of security concerns). The unfortunate finding, however, is that programs like ARCI are largely the result of individual program office initiative. There do not appear to be the incentives in place to foster proliferation of this model.

SUMMARY

The SYSCOMs and program offices differ with regard to how they count IETMs and with regard to the categorization of the various IETM classes. This situation

has led to large accounting discrepancies. Consequently, performing an accurate audit of the Navy's total cost in acquiring IETMs is difficult. The Navy can rectify this problem partly by adopting a directive that states a clear definition of an IETM and the various classes of IETMs and ensuring that the SYSCOMs and program offices understand and use these definitions.

Furthermore, SYSCOMs do not collect cost data associated with IETM development, acquisition, or conversion. If the Navy truly wants to understand the extent of its IETM investment, it will have to encourage and possibly direct a cost reporting framework and *require* program offices to collect this type of data. Benefits, whether operational or training, will remain meaningless without a clear understanding of their associated costs.

Although we did not explicitly examine the operational benefits of using IETMs, there is some indication from earlier work that the benefits can be significant. These benefits might include reduced repair times and fewer false removals. Collecting this type of data, however, requires a concerted effort on the part of the operational community.

Resource sponsors and decision makers who are considering whether to resource the acquisition of technologies such as IETMs often will establish return on investment (ROI) goals as decision criteria. IETMs have no monetary returns in and of themselves; they claim all of their benefits through life-cycle cost savings.⁷ Therefore, the operational benefits attributed to the use of IETMs also must be converted into monetary returns or savings so as to facilitate a robust benefit analysis. To date, very little experience data of this type have been collected with which to provide solid operational insights.

⁷ James R. Carlberg, Raymond P. LeBeau, Theodore J. Post, Steve Connell, and Mark Armijo, *Aviation Maintenance Environment (AME) Cost Benefit Report*, NSWC Carderock Division, May 1998.

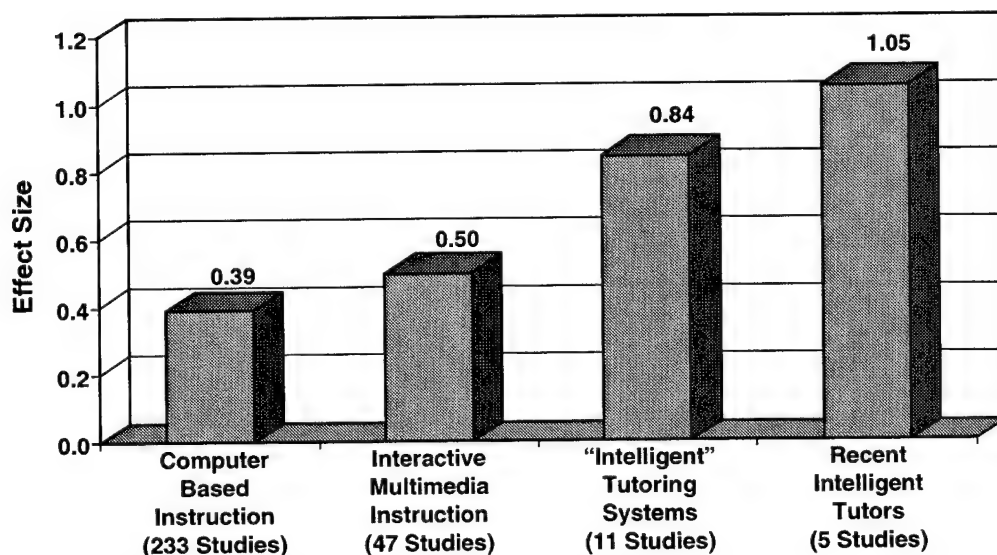
Chapter 4

IETMs and Navy Training

GENERAL

People who plan and resource training generally accept the notion that training technology can positively affect training outcomes. The roles and impacts of various training technologies have been the subject of many recent studies. The DoD Total Force Advanced Distance Learning Action Team (TFDLAT) collected the results of several industry and academia-produced studies that attribute impressive levels of cost reduction, training time reduction, and skills enhancement to situations in which students are “technology-assisted” (see Figure 4-1). This assistance ranges from Video Teletraining (VTT) to Web-based interactive multimedia instruction (IMI). On the basis of this research, the TFDLAT concluded that technology-assisted training reduces training costs by 30–60 percent; it also either reduces training time 30 percent or increases post-training skills by about 30 percent.

Figure 4-1. Some Effect Sizes for Technology-Based Instruction



Source: DoD TFDLAT Web site: <www.adlnet.org/TFDLAT.htm>.

Navy leadership believes that there are opportunities for resource savings in its individual skills training domain through prudent application of training technology. Acting on that belief, the Navy has begun an aggressive classroom modernization program it calls “training reengineering.” The heart of the reengineering program is a suite of automation aimed at enhancing training and learning experi-

ences. IETMs usually are deployed with that automation suite. In fact, for technical training, IETMs represent the key source of data required to implement the classroom reengineering.

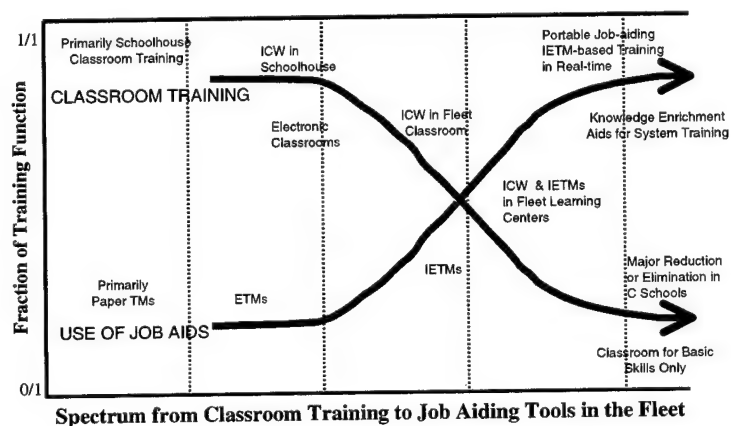
The Navy presumes that IETMs will

- ◆ enhance classroom training for technical specialties, allowing the Navy to reduce or eliminate schoolhouse training;
- ◆ support job-site training by giving trainees access to training resources any place, at any time; and
- ◆ encourage the definition and development of a shared IETM and training database.

In fact, there is a body of research on benefits to the training community of incorporating training functionality into IETMs. NSWC-CD performed much of that research before 1997. This research suggests that if IETM planning and development fully integrates the needs of the training, maintenance/logistics, and operational domains, each domain can realize noteworthy gains.

For the training community, the potential benefit and cost savings could be tremendous. Specifically, training functions could be performed at the job site, which would obviate the need for dedicated institutional training for those functions. The graphic in Figure 4-2 implies that some or all of the C-school curriculum for some specialties could be eliminated with the prudent use of sophisticated devices.

Figure 4-2. Potential IETM Classroom and Job Site Impacts



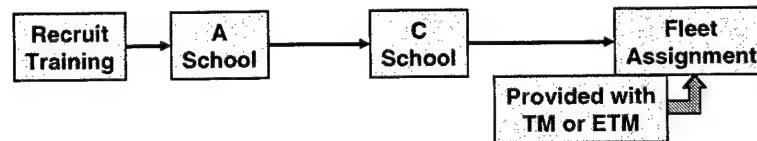
Source: E. L. Jorgensen and J. J. Fuller, *New Approaches for Navy Technical Training and Job Performance Aiding using Expanded IETM Technology*, Carderock Division Naval Surface Warfare Center, October 1996, 8.

NAVY INDIVIDUAL SKILLS TRAINING

Training Process

The Navy's typical pattern for schooling of technical disciplines is shown in the flow chart in Figure 4-3.

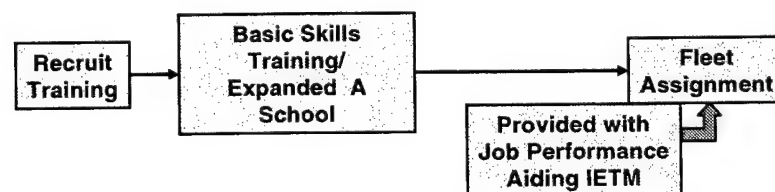
Figure 4-3. Typical Navy Training Approach



The trainee is awarded a specialty and attends an A-school to receive the basic skills required to perform that specialty. The trainee then attends a C-school to be trained on higher-order skills required to perform diagnostics and repair of sophisticated equipment. At the C-school, the trainee is certified "proficient" (beyond an apprentice level) to operate and maintain the equipment to which he or she will be assigned.

A "new" approach shown in Figure 4-4—suggested by research conducted by NSWC—contends that effective use of IETMs in the classroom could enable the training base to train selected students on basic skills as well as some advanced techniques in one setting. This approach would obviate the need for some or all C-school training for affected specialties.

Figure 4-4. IETM-Enhanced Training Approach



The expanded skills training would not attempt to combine all of the A- and C-school training. Instead, it would train only the most common or frequently used techniques and information. Less-common or less frequently encountered situations would be learned on an as-needed basis at the technician's operational assignment (i.e., the Fleet). This on-the-job training (OJT) could be conducted via self-paced exercises by the technician or as formal OJT monitored by a unit trainer. The trainer would use the embedded interactive courseware component of an enhanced training- or performance-aiding IETM.

We were unable to uncover any experiential data to suggest whether the proposed Carderock model would be feasible or infeasible. Certainly, some Naval Enlisted

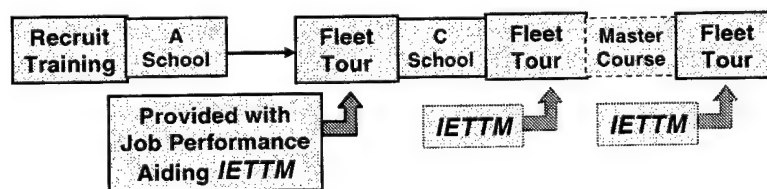
Classifications (NECs)—for example, information technology (IT)—have commercial or civilian equivalents, and courseware may be bought off the shelf to replace some classroom training. Many military specialties, however—such as fire control specialists (FCs)—have no civilian counterparts, and the military would have to invest heavily to create self-paced courseware. In fact, advances in instructional technology probably would have to occur so that high-level simulations and feedback could be incorporated into such a device economically.

Trainers we interviewed expressed understandable concern over the alternate approach. Their primary concern is that pushing C-school training functions to the Fleet would limit the quality and depth of training students receive. Much of the C-school curriculum—as we observed in the GS course—addresses concepts at a theoretical level that provides the breadth necessary for these technicians-in-training to think “outside the box” when they return to the Fleet. In addition, pushing C-school responsibilities on the Fleet will likely affect the operational performance of the ship as junior and senior sailors attempt to balance training and operational responsibilities. Moreover, qualified instructors for each such training requirement may have to be detailed to the Fleet.

Each of these developments would run counter to the optimum manning paradigm of the SMARTSHIP concept or the “zero-based” crewing concept of the DD-21.¹ These new concepts call for limited apprenticeship opportunities. NTC Great Lakes instructors recommend limiting the amount of training onboard ship to refresher training only.

CNET has suggested a second alternative to the base model (Figure 4-5).² The CNET model further leverages the capabilities of job performance-aiding devices. In fact, the device in the CNET model would be called an Interactive Electronic *Training* and Technical Manual (IETTM). Developed with training requirements assuming as much importance as technical functionality, this device would have several levels of interactive courseware built in.

Figure 4-5. CNET Suggested Training Model



The CNET model calls for reducing the A-school content to be more easily managed by the young sailor. Many lower-density duties and functions would be included in the enhanced IETTM, and the sailor would learn them by using a self-paced, just-in-time method during his or her Fleet tour. As the sailor advances, he

¹ DD-21 Web site at <<http://sc21.crane.navy.mil/dd21/program/overview.htm>>.

² Interview with Terry Halvorsen, CNET, 15 August 2000.

or she would attend a reduced-scope C-school and a "Master-level" school, both at the Fleet Concentration Area. The IETTM would recognize the increased cognitive capabilities of the user and structure further self-paced training and performance aiding to match the user's requirements.

Savings in this model relative to the current approach would come from the reduced length of the A-school and the reduced size and greatly reduced temporary assigned duty (TAD) requirements of the Fleet C-schools. CNET contends that, unlike the Carderock model, this model is gaining some support from the Fleets and the training community.

The CNET approach holds some intriguing possibilities. It clearly assumes that the training and education community could reconfigure to support the increased number of Fleet C-schools and that the acquisition and training communities could work out some complicated collaboration and funding issues. It also places heavy reliance on having a robust job aid that supplements classroom training. This model is worth exploring.

Navy Training Technology

The Navy's training reengineering program seeks to reduce the time and resources required to conduct skills training by infusing training technology into the classroom and by updating training curricula to maximize the effectiveness of the new technology. The basic classroom reengineering piece consists of AECs, Learning Resource Centers (LRCs), and Interactive Multisensor Analysis Trainers (IMATs).³

AECs promise increased classroom efficiency and effectiveness by making classrooms interactive, multi-media learning vehicles. LRCs, to be located at selected schools and training sites, provide alternate means for students to access curriculum training materials and professional enhancement material in electronic formats.⁴ LRCs are intended to reduce training attrition and save student billets by moving students out of formal training and into the Fleet sooner. IMATs are intended to make hands-on training more effective. The cumulative result should be reduced training time per student and fewer required refresher courses.

IETMs AND TRAINING

The acquisition/logistics community procures TMs that are targeted mainly to maintenance and logistics purposes. Training courseware, of course, is procured by the training community. Developing IETMs that will serve these two ideological masters is a challenge. Given the current Navy infrastructure and the way sup-

³ Draft CNET Instruction, "Return on Investment (ROI) for Training Reengineering Investments," 1999.

⁴ Department of the Navy, POM-00 Training Baseline Assessment Memorandum, 23 March 1998, Tab A-2.

port documentation is maintained, IETM developers must provide a means for separate technical manual and training documentation deliverables, if both are developed concurrently. If they are delivered separately, developers should provide a means for updating them that ensures that they will remain consistent with one another.⁵

There are numerous examples of IETMs that have been used—in classroom situations and outside them—to facilitate technical training. Observers generally accept that at least a Class 2 or 3 IETM is required to provide the navigation functionality necessary to efficiently train on complicated topics. For practical exercises and low-density training events, an IETM with courseware integrated can be used. Higher-level IETMs also can be structured to recognize the level of the user and tailor OJT and remedial training for the specific user, as well as to update the user's learning category as lessons are successfully negotiated.

Advocates assert that incorporating IETMs into training will result in a reduction in classroom hours required to conduct technical training. This result also may lead to other benefits, such as reductions in the number of instructors required, reductions in the number of people in the training pipeline, and shorter pipelines. They contend also that because IETMs should make technical training more effective, grade-point averages will improve and attrition rates will go down.

Training-IETM Interface

To facilitate training with IETMs, a major interface between the training development and the IETM development processes clearly must be considered. The Navy's guide for approaching this interface delineates four strategies:⁶

- ◆ *Coordinated* (exchanging files, interfacing software)—independent IETM and training product development with planned and coordinated exchange of IETM files, software, and so forth for interface with automated curriculum development programs
- ◆ *Concurrent* (developing some shared data, sharing/interfacing software)—simultaneous, planned, and coordinated development of IETM and training support products, particularly development and use of shared data and software; initial joint planning and requirements determination enable data integration into training curriculum
- ◆ *Integrated* (developing a shared database; sharing software)—structured, concurrent, and shared development of all maintenance, operations, and training materials into a single, fully integrated database that uses multiple tailored-view packages to present material to various users

⁵ DON, *Training/Interactive Electronic Technical Manual Interface Guide*, March 2000.

⁶ Tri-Service Technical Manual Working Group (NTMWG), *Draft Interactive Electronic Technical Manual (IETM) Process Plan (IETMPP)*, February 1998, sec. 8.2.1.

- ◆ *Embedded*—combining all requirements and materials into an integrated database with a single view package so that training materials are indistinguishable from maintenance, operations, and other materials, enabling operations, maintenance, and training personnel to use a single product.

There are several advantages to interfacing ICW with IETMs. From an operational/maintenance perspective, the user can access content-specific instructional text, graphics (static or dynamic/animated), and/or video to enhance or assist with technical concepts or procedures. From the training perspective, having an interactive electronic technical database available during an ICW-supported lesson makes possible access to realistic technical information that is extensive in depth and scope. All of the necessary learning elements (such as menus, objectives, and embedded questions) can be resident in the ICW; specific technical data (text, graphics, and video) reside in an underlying IETM database. Tying ICW to IETMs also provides instructors with an on-time reference. The higher classes (4 and 5) have the greatest potential to affect how maintenance training takes place.

IETM Costs

To get the most from IETMs in the classroom, they must be employed with other AEC components and have associated interactive courseware. This fact complicates forecasts of IETMs' costs and impacts. If AECs are in place for the planned IETM application, the cost-benefit ratio will be one value. If not, the cost-benefit ratio will be a different—probably significantly lower—value. An assessment of potential costs and savings for IETMs, however, should account for AEC suite investment costs if AECs are not already in place.

There also are life-cycle support costs to consider. These recurring costs relate to the use of IETMs in a training environment or in an operational environment. The cost of performing technical manual updates and changes is one recurring cost that often is cited as a *benefit* of IETMs over paper manuals. Navy organizations may save significant time and money posting and implementing updates and changes with IETMs rather than with paper manuals. The magnitude of the savings will depend on the media and method for updating the IETM, the class of IETM, and the number of paper changes/pages affected, among other factors. Anecdotal information from NAVSEA sets the savings (or cost avoidance) for updating IETMs at about one-fourth the cost of updating comparable paper manuals.⁷

The costs of updates vary widely, depending mainly on the frequency and complexity of the updates and the means of distributing the changes.

⁷ Martin Cohen, NAVSEA Ships Systems Engineering Station, Philadelphia, PA, 14 September 2000.

In addition to hardware and courseware acquisition costs, there also are costs for converting the A- or C-school course and then implementing reengineered courses.

IETM Benefits

The experts we spoke with claim to have observed the following major benefits of using IETMs:

- ◆ Cost savings for printing, distribution, maintenance, and storage (as described in Chapter 3)
- ◆ Reduced life-cycle support costs related to changes and updates
- ◆ Improved training experience reflected in reduced classroom time and improved grade-point averages:
 - assists instructional material development process
 - reduces TM navigation time
 - increases student comprehension⁸
- ◆ Improved maintenance operations due to more efficient technicians

We reiterate, however, that these benefits are very difficult to verify empirically because of the lack of captured data. Moreover, the IETM usually is introduced into training at the same time that the school incorporates the AEC. Trainers and curriculum developers also are making compound changes as they incorporate AEC/IETMs into their courses. The Sub School, for instance, in addition to installing AECs, significantly changed the curriculum for most affected courses. In some cases, they increased the course content by an estimated 30 percent. Thus, isolating the change that one may attribute to the IETM is very difficult.

Training institutions we researched are realizing training time reduction—but not of the magnitudes some previous studies presumed. Courses we surveyed did realize 10–15 percent time-to-train reductions (not the 30–40 percent savings predicted by early studies). Also, instructors still must take time to manually create Microsoft PowerPoint presentations with which to conduct instruction. There are no significant changes in student-to-instructor ratios or graduation rates—measures commonly referred to in concept studies.

The GS school, for instance, was able to reduce course length by about 10–12 percent with the installation of its AECs.⁹ Although this figure represents signifi-

⁸ Telephone interview with Lt Cdr Brian Little, Navy Sub School, New London, CT, 20 June 2000.

⁹ Interview with Commander William Hawn, Officer-in-Charge Engineering Systems Schools, Great Lakes, IL, 21 June 2000.

cant savings if extrapolated to more and larger courses, it is well short of the approximately 30 percent classroom training reductions that some of the current literature assumes.

This reduced course time eventually should lead to reduced time for students in the training pipelines and less TAD requirement, but schools we contacted are not seeing shorter pipelines to date. The staffing and personnel management impacts of having IETMs in the schoolhouse and at the Fleet also must be evaluated. There may be more efficiencies and savings in these domains, as well as to the Navy as an enterprise, if training and education pipelines shorten for some technical specialties.

Impact of IETMs on Training

IETMS AND CLASSROOM TRAINING

Recent Navy research shows a trend of increasing demand for new NECs in the Navy. A Navy survey of the Truman Battle Group revealed that more than 70 percent of new or upgraded systems deployed were supported by some form of training. About 25 percent of these required that either a new NEC or an increase in the number of personnel holding current NECs be assigned onboard.¹⁰

For each new NEC, the Navy must create, implement, and sustain an individual skills training program, mainly in institutional settings. The cost to train sailors in an NEC can range from \$5,000 to \$25,000.¹¹ If the use of IETMs could replace some of this training, the Navy could save significant amounts of training resources.

CNET has compiled “before-and-after” time and cost statistics on the AEC installations they have made since 1997. (Caution: The figures in the following illustrations include the total time students are charged against training accounts, not just classroom training time.) Anecdotal CNET data for electronics technician (NEC ET) (communications and radar) A-school training indicate large reductions in time-to-train: about 837 man-years (of 2,710 possible). The cost associated with these time savings is about \$30 million—or about one-third of what was traditionally spent for those courses before reengineering. CNET estimates that on average it is realizing man-year savings of about 8–15 percent for courses like these.

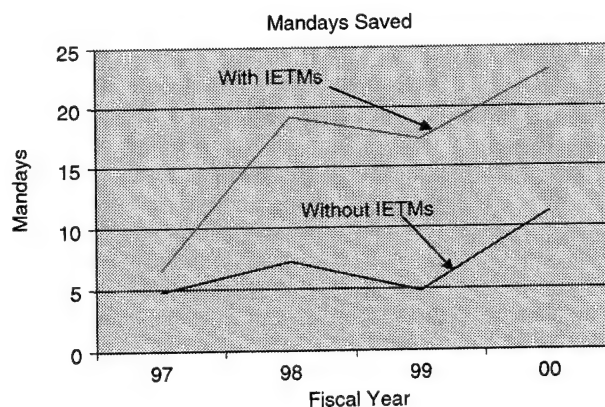
As we have noted, measurement of the specific impact of IETMs in training settings is complicated by the lack of available data and the absence of any clean way to “back out” IETM effects. We can get some insights into the IETM contribution, however, by evaluating some gross results from AEC deployments. Fig-

¹⁰ OPNAV N81, Assessment Division briefing, “Training and Education IWAR Individual Skills Assessment Process,” 5 September 2000.

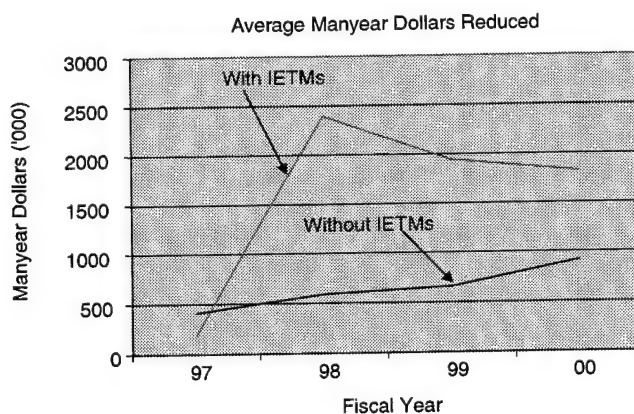
¹¹ Interview with Maureen Davidovich, OPNAV N7, 10 October 2000.

ures 4-6 and 4-7 show CNET data for reengineered training courses—some of which had IETMs incorporated into the AECs and some of which did not.

*Figure 4-6. ET A-School Reengineering
(Average Days Saved)*



*Figure 4-7. ET A-School Reengineering
(Average Dollars Saved)*



The sample size that these data reflect is very small (20 courses), so the statistical significance of the results is not very high. One may conclude, however, that there probably is a positive difference between time and cost savings achieved in courses with IETMs and those without the devices. CNET estimates that IETMs may account for about 10–15 percent of the 8–15 percent in training dollars saved as a result of installing AECs. That savings amounts to about \$2.5–\$3 million to date for ET A-school courses alone.

One of the more important aspects of the Navy's training reengineering strategy is that it creates the requirement for a new evaluation measure of effectiveness—return on investment. Before making the investment in training technology, the Navy must make an assessment that it will realize a monetary savings by making

that investment. The Navy has established an 8 percent return in 2 years as the standard. CNET currently interprets ROI to be the net of monies invested in reengineering and postulated savings from (presumably) reducing training time per student.

IETMS AND JOB-SITE TRAINING

The concept of incorporating training into IETMs for the benefit of the technician at his or her work site was explored in a recent test that used aircraft platforms. The Aviation Maintenance Integrated Diagnostics Demonstration (AMIDD) tested the operational maintenance efficiency effects of using off-aircraft diagnostics with computer-aided maintenance techniques. The test showed that the use of IETMs greatly improved the diagnostic and maintenance results of the technicians. The testers also concluded, however, that integrating training into this concept is important. They wrote:

The similarities between the data used to develop Computer Based Training (CBT) and Interactive Electronic Technical Manuals (IETMs) should allow for a seamless integration of the two to either share data fields and reduce duplicate data or at least linking the databases. This will allow for single data input for training and technical manuals. This will enhance training in the classroom and in the fleet as the maintainer will be able to launch from training applications into the applicable technical manual or vice versa.¹²

According to N7, ICW and job-aiding technologies are converging. With this in mind, some programs are approaching the issues of training and maintenance/logistical support as related. They foresee tangible and intangible benefits of fully integrating their plans for maintenance and logistics with their training plans. One such program is ARCI. This program and the Virginia Class Sonar, Combat Control, Architecture (S/CC/A) program are building to an Integrated Development Program (IDP) that would concurrently develop training and logistics products across both programs. The purpose is to increase asset utilization and reduce costs for both programs. The ARCI team has logisticians and trainers working together to create IMI that will communicate directly with the system's IETM to provide "a seamless interface between the IETM and IMI."¹³

When system developers are designing new systems, they are required to consider the training implications of the item and even to incorporate embedded training systems, if feasible. The real key appears to be to minimize the human interface requirements of the end item design. Fewer human interface requirements mean fewer topics requiring training. For training requirements that remain, use as smart a performance aid as possible. If the IETM is designed with the intelligence

¹² J. R. Carlberg et al., *Aviation Maintenance Integrated Diagnostics Demonstration (AMIDD) Test Report*, Carderock Division Naval Surface Warfare Center, 1998, 32.

¹³ Lockheed Martin Undersea Systems, *Integrated Development Program Integrated Support Plan*, 1 November 1999, 6-5.

to know what tasks the user needs training on, it can be used effectively within the scope of a planned training continuum.

SUMMARY

We found that IETMs are not yet widely disseminated in training venues. Where they are in classrooms, IETMs generally are incorporated into training as part of a larger course reengineering. This fact makes assessing their impact empirically nearly impossible without a controlled test or pilot.

Training technology suites are not yet achieving time and cost savings in the magnitude theorized in early studies. IETMs' contribution to the realized savings is probably about 10 percent. In addition to providing training capability to the job-site, IETMs in operational settings also results in improved maintenance operations.

The greatest potential benefits for training occur with devices that have higher degrees of interface between technical data and training courseware. Achieving these levels of interface routinely, however, probably requires an increased level of involvement by the Navy's acquisition management leadership.

Chapter 5

Findings and Conclusions

GENERAL

In this chapter, we summarize the major findings and conclusions discussed in the preceding chapters. We have reduced the issues to the four that we believe provide the most insight to the Navy. Where appropriate, we also suggest ways the Navy may address these issues.

ASSESSING IETM COST-BENEFIT

Findings

Probably the overarching conclusion from this research is that drawing conclusions about the Navy's costs and benefits that come with using IETMs will be extremely difficult. An objective and robust cost-benefit analysis is nearly impossible in the short term, for several reasons.

First, it may be too early in the evolution of IETMs to draw meaningful conclusions about their return on investment or their long-term impact on readiness. A good cost-benefit analysis must be able to extrapolate IETMs' experience in operation over a "life cycle." Military schoolhouses are only now integrating IETMs and electronic classrooms into how they do business. These systems are experiencing predictable growing pains. There also is a lack of practical experience with sufficient numbers of mature, fielded systems.

We found that the organizations in the best positions to collect data concerning IETMs costs and benefits don't. Neither the Service School Command (SSC) at Great Lakes nor the Submarine School at New London routinely records changes in course length, student scores, or student throughput capability resulting from the insertion of technology into their classrooms. SYSCOMs had no operational experience data on which to base their acquisitions.

The major problem with obtaining impact data is that IETMs are almost never deployed in isolation. They are fielded as part of a suite of training technology in their incorporation in classrooms. At operational sites, the introduction of IETMs often is accompanied by other operational improvements. Extracting the effects one may attribute to the presence of IETMs is difficult.

We also encountered significant roadblocks to efficiently obtaining cost data. Sometimes the data are doggedly guarded by the manufacturer or the government

program office. In other cases, the data are buried in CLS documentation. Because of the wide range of approaches to acquiring IETMs, some data are unique and therefore are difficult to combine with analogous data from similar systems.

Conclusions

There is a critical need for cost and benefit data. To understand the full potential impact of IETMs on training and operations, the Navy will have to be able to say where the dollars are going, what it is getting for those dollars, and what return it may expect for future expenditures. Until such empirical evidence is available, IETMs' advantages or disadvantages will continue to be speculative. Collecting data and making it available may require flag officer involvement at the OPNAV, SYSCOM, and training command levels to encourage the pertinent organizations to capture the data.

There are many mechanisms for obtaining usable data for an analysis. One of the best means of assessing IETMs' cost/benefit is to conduct a scientifically designed pilot project. Researchers may use two comparable classes and collect experience and results data as one class trains with IETMs and the other trains without the devices. Alternatively, IETMs can be introduced into a course for which results are already documented. In this case, researchers would compare "before and after" observations. These experiments also can be conducted at operational job sites.

IETM ACQUISITION POLICIES

Findings

The Navy exercises little management oversight of IETM development and acquisition. The process is decentralized to a fault. There is no central guidance or authority to which acquisition program offices can look for the big picture. Potential efficiencies and savings may never be realized without directive intervention by Navy leadership.

Although the Navy has published general guidance that asks acquisition program managers to acquire digital technical information where it is deemed "cost effective," there are no related guidance documents that address how programs should determine cost effectiveness.

Navy acquisition programs acquire IETMs based almost solely on maintenance and logistical criteria. Training rarely plays a role in defining the type and class of device a program acquires. Logistics and training stovepipes exist that severely limit the amount of interaction these two communities exercise.

The widespread use of proprietary software clearly hampers the cost-effective acquisition and employment of IETMs. A prime benefit of COTS technology is that

systems may be constantly upgraded and improved at modest or no cost to the government. This factor, of course, is in keeping with AEC imperatives. All acquisition programs should acquire COTS technology or rights to IETM software for the government.

Conclusion

The Navy could benefit by establishing a “lead” office—probably in the office of ASN(RDA), with representation from N4 and N7, among others—to serve as the defining authority for IETM acquisition. This authority must establish an overall acquisition vision that breaks the “rice bowl” mentality that permeates the current process.

One of the first tasks for the lead office would be to develop consistent, measurable definitions for IETMs so that all stakeholders are counting the same things. The lead office also would define the cost effectiveness metrics that PMs would use to conduct their business case analyses. The office must address the issue of proprietary viewer software and develop and enforce interface and functionality standards.

BUYING IETMS

Finding

Most IETM-specific development costs relate to software development. These costs have less to do with the volume of information and likely are in proportion to the complexity of the item and the level of interactivity and functionality the user desires. The actual conversion or coding, however, does incur a value-driven cost.

The predominant reason that Navy programs acquire IETMs is to save the high operations and support (O&S) costs associated with paper technical manuals. In general, programs are buying the lowest-class devices, without much analysis to understand how matching the class of IETM to the anticipated maintenance or training tasks may affect their ROI.

Conclusion

Regardless of whether the Navy wishes to assess the relative costs and benefits of IETMs to address training and education issues, there should be a concerted effort to put data structures in place to assess whether the Navy is spending its technology dollars wisely. The Navy would benefit from a comprehensive review of its acquisition cost reporting requirements, education and training database structures, and logistics data management and reporting requirements to determine if data capture capabilities are sufficient to address routine cost-benefit or ROI queries.

If avoiding the high O&S costs of legacy manuals is a compelling reason to acquire IETMs, the Navy should study ways to attack these costs as an enterprise. This strategy would require the involvement of all resource sponsors and claimants who work with technical data.

The study must first determine as many of the factors that influence the high O&S costs as possible. Then the Navy can determine which of those factors can be controlled for the greatest O&S cost/savings impact. Alternatives such as directing acquisition and distribution of various classes of IETMs, investing in wearable computers, developing a Web-based repository of all technical data, or other approaches could be modeled to determine the best corporate approach.

IETM TRAINING BENEFITS

Findings

Although there are some observed benefits to using IETMs in training, users are not yet seeing the dramatic time and cost savings that earlier studies predicted. Reengineering of classroom training is resulting in better student performance and some course length reductions. We temper this finding with the admission that we cannot draw firm conclusions about the cost-benefit ratio or ROI of IETMs because we cannot isolate benefits specific to IETMs.

Several technology initiatives are being promulgated throughout the Navy simultaneously, but their effects may be watered down unless the initiatives' proponents are cognizant of one another and all relevant parties are *required* to comply with certain imperatives.

Conclusions

If one logically assumes that there are fiscal and operational benefits to using IETMs rather than paper manuals, the Navy would be wise to devise a plan that "stacks the deck" to achieve the maximum impact of these benefits by considering how IETMs relate to these other initiatives.

Intuitively, we believe that there should be a blend of investment in electronic classrooms and in distributed learning technology. The effective combination of these investments should reduce staff downtime, enable independent learning, and greatly reduce training pipelines. The IETM is one technology common to both venues. Integrating Web-based training with IETMs serving as Electronic Performance Support Systems (EPSS) should support the learning continuum and replace some formal training.

The Navy might wish to determine the optimum mix of classroom modernization and distance learning investment. One of the objectives of the Navy-wide Distributed Learning Planning Strategy is to *reduce* the Navy's reliance on classroom

training. In addition, there clearly is potential for training and operational benefit to the Fleets by effectively employing IETMs, Web-based training, and performance support systems. The Navy may want to consider conducting low-level pilots to understand the synergistic effects of these innovations.

Finally, when the potential and implications of these technologies are understood, the Navy may develop a plan for cost-effectively deploying the appropriate systems and establish realistic goals for cost savings and benefit returns. The Navy clearly could benefit from developing a model that can assist in the technology assessment and selection process.

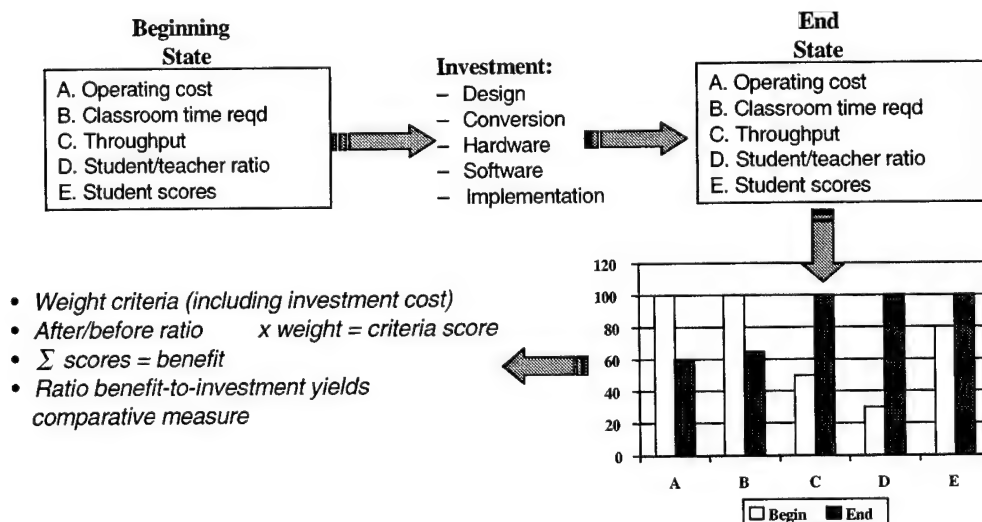
The objective of such a model may not be to determine a categorical “winner” among discrete alternatives. Instead, it may identify and assess the differences in costs and benefits among the alternatives, with the aim of characterizing the tradespace available to decision makers. Although this process may not determine an overall “best” alternative, it will suggest a way to find the best fit given decision makers’ priorities and constraints.

Because many of the anticipated benefits of employing IETMs in institutional schooling and Fleet environments cannot be quantified readily in monetary terms, we suggest that analysts not attempt to compute net cost-benefit or benefit/cost ratios. The best way to analyze the purely economic costs and benefits is by computing the savings/investment ratio (SIR). That formula is as follows:

$$\text{SIR} = \frac{\text{Baseline Cost} - (\text{Cost of Alternative} + \text{Investment})}{\text{Investment}}$$

The Navy might wish to use something akin to the methodology in Figure 5-1 to rank alternative approaches. This methodology evaluates combined “important” factors—quantifiable and nonquantifiable—as determined by decision makers.

Figure 5-1. Cost-Effectiveness Model



Unlike a dollar-return-for-dollar-spent ROI model, this type of framework enables planners to establish the *relative* benefits of proposed technology insertions. This methodology simply is a generalization of conventional cost-benefit analyses that combines the contributions of multiple criteria into a single, unitless measure and allows the analyst to rank options according to the analyst's preferences. The criteria—which are notional here—could be determined through research, or they may be whatever “important” factors the user chooses. Our experience suggests that at least one measure each for cost, effectiveness, and efficiency would be appropriate for assessing the impact of training technology investments.

This framework requires the user to quantify the *difference* in these important factors, from before a technology insertion to after the insertion. It results in a benefit gained (or lost) per unit of cost for each option, enabling planners to compare dissimilar options. For a proposed technology insertion, this model assumes that insertion-specific investment costs can be estimated and that all evaluation criteria can be quantified, though not necessarily in economic terms. This analysis may even be on a subjective scale. Clearly, an increase may be desirable for some criteria and undesirable for others (e.g., student throughput versus classroom time required). These relationships can be accommodated in the criteria weighting. If desired, that same weighting system can be used to express all criteria in terms of their economic impact for a pure cost-benefit assessment.

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Appendix

Abbreviations

AEC	Advanced Electronic Classroom
ADLI	Advanced Distributed Learning Initiative
AIMSS	Advanced Integrated Maintenance Support System
AMIDD	Aviation Maintenance Integrated Diagnostics Demonstration
ASCII	American Standard Code for Information Interchange
ARCI	Acoustic Research COTS Integration
ASN(RDA)	Assistant Secretary of the Navy for Research, Development and Acquisition
CALS	Continuous Acquisition and Life Cycle Support
CLS	Contract Logistics Support
CNET	Chief of Naval Education and Training
CONOPS	concept of operations
COTS	commercial-off-the-shelf
EPSS	Electronic Performance Support System
ET	electronics technician
ETM	Electronic Technical Manual
FC	fire control specialist
GS	gas turbine maintenance specialist
HM&E	hull, mechanical, and electrical
ICW	interactive courseware
IDP	Integrated Development Program
IETMPP	IETM Process Plan
IETM	Interactive Electronic Technical Manual
IMAT	Interactive Multi-sensor Analysis Trainer
IMI	interactive multimedia instruction
IT	information technology
NATEC	Naval Air Technical Data and Engineering Service Command

LRC	Learning Resource Center
NAVAIR	Naval Air Systems Command
NAVSEA	Naval Sea Systems Command
NAWC-TSD	Naval Air Warfare Center-Training Systems Division
NEC	Naval Enlisted Classification
NSWC-PHD	Naval Surface Warfare Center-Port Hueneme Division
NTC	Naval Training Center
O&S	operations and support
OJT	on-the-job training
OPNAV	Office of the Chief of Naval Operations
PDF	Portable Document Format
PEDD	Portable Electronic Display Device
PM	Program Manager
QA	quality assurance
ROI	return on investment
S/CC/A	Sonar, Combat Control, Architecture
SecNav	Secretary of the Navy
SCORM	Shareable Courseware Object Reference Model
SGML	Standard Generalized Markup Language
SIR	savings/investment ratio
SPAWAR	Space and Naval Warfare Systems Command
SSC	Service School Command
SYSCOM	system command
T/IIG	Training/IETM Interface Guide
TAD	temporary assigned duty
TDMIS	Technical Data Management Information System
TFDLAT	Total Force Advanced Distance Learning Action Team
TM	technical manual
TMDR	technical manual deficiency report
VTT	Video Teletraining
VTUAV	Vertical Takeoff and Landing Unmanned Aerial Vehicle
XML	Extensible Markup Language